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ABSTRACT

Implications for Maine's vocational technical institutes of changes in the pulp and paper industry are examined in this study designed to help vocational educators realize the importance of keeping current with the needs of employers in relevant labor markets. Information used was gathered from relevant literature and from indepth interviews with instrumentation supervisors in eight paper companies in Maine. Although emphasis is placed on the paper and pulp industry and the role of the instrument technician within this setting, this study also provides a general description and analysis of the difficulties involved in keeping an occupationally oriented education program up to date with the needs of major employers in the relevant labor markets. The following major topics are covered: Role and Impact of Maine's Paper Industry, Technological Change in the Pulp and Paper Industry, Employment Trends, Changing Role of the Instrument Technician, Current Methods of Skill Development, Career Opportunities in Instrumentation, Necessary Training and Background for Instrumentation, Summary and Conclusion of Results, A Conceptual Framework, and Recommendations for Vocational Education. The three appendixes include the study's methodology, the interview guide, and a sample course description for the first two years of a 4-year apprenticeship program in instrumentation. (SH)

THE IMPACT OF TECHNOLOGICAL CHANGE UPON THE INSTRUMENT TECHNICIAN IN THE PULP AND PAPER INDUSTRY AND SOME IMPLICATIONS FOR VOCATIONAL EDUCATION

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Abstract

It is important that vocational education be kept current with the needs of employers in relevant labor markets. This study examines the implications for vocational technical institutes in Maine of changes in the pulp and paper industry, one of the State's largest and best employers. The study shows that there are many job changes occuring in the industry (new jobs or changes in existing jobs) as a result of legislative and technological developments. Most of the job changes have little implication for VTI education since the changed occupations call for fewer skills or new skills which can best be met by the employer through on the job training or other similar devices. Instrument technician or repairman is an exception. This well-paid, high status occupation is the keystone of many of the new technological developments and the job is calling more and more for skills and knowledge, much of which probably can be most efficiently taught by VTI's. Whether this will result in a larger demand for VTI graduates trained in instrumentation is only problematic since this would entail a significant change in the structure of the labor market in most paper firms. Present methods of developing needed skills are reviewed and recommendations are made for a wider role by vocational education.

INTRODUCTION

Vocational education has two important roles to perform: (1) to provide students with occupational skills for immediate employment and a foundation for further growth and skill development; and (2) to provide human capital for employers since skills play such a critical role in almost every sector of the economy. Therefore it is important that vocational education in Maine be kept current with the changing needs of employers in the state. This study sets out the implications for vocational education for some of the changes taking place in the paper and pulp industry, one of the state's largest and best employers. The study has an additional outcome, a more general description and analysis of the difficulties involved in keeping an occupationally oriented education program up to date with the needs of major employers in the relevant labor markets. The latter can be considered as a conceptual framework to aid further research along this line. Although originating from the work on the paper and pulp industry, the analysis is also based on well established labor market research. Nevertheless the framework should be only considered as a working hypothesis to be adjusted, changed, or perhaps discarded as results of other industries are added to our knowledge.

Changes in jobs and job requirements can come from several sources. One such source is legislative. OSHA is a good illustration of legislative change imposed by a greater awareness for the health and safety of production workers. Environmental regulations are a result of a growing concern over pollution. Such legislative developments have caused changes in existing jobs as well as the creation of new skill requirements. A second important basis for change is technological developments, either new techniques of production or new products. A third source would be growth--new industrial development in the labor market served by a particular vocational education system. The implications for vocational education of job changes caused by the new environmental laws and new technological developments in the paper industry are investigated in this report.

There does not seem to be any clear cut methodology either for identifying changes in jobs or job requirements arising out of developments such as those occuring in the paper industry or for pinpointing those changes which are most relevant for vocational education. Some of the literature in the field suggests the use of the new Occupational Employment Statistics Program of the Bureau of Labor Statistics being carried out by the Manpower Research and Development division of the Maine Employment Security Commission. Other sources would include the Dictionary of Occupational Titles or the Classified Index of Industries and Occupations of the Bureau of Census. None of these sources proved to be of any use in identifying new jobs or changes in jobs, let alone identifying those changes with the greatest impact on vocational education. It is fair to say that there is no systematic source of information that provides specific enough information relevant to the needs of vocational education. One must rely almost completely on discussions with knowledgable persons in the industry.

In this study initial contact with several persons closely allied with the paper industry along with interviews with personnel directors in several firms. These interviews explored the effects on job requirements and job skills resulting from changes in the process of making paper as well as the new environmental laws. These developments were causing new jobs to be created and important changes in existing jobs. Most of the changes had little implication for vocational education because the new or changed job requirements could usually be handled most efficiently internally with on-the-job training or short, ad hoc, training programs. The conclusion of most of the people interviewed was the one job that has shown the largest change in skill requirements of a kind than can be appropriately and efficiently handled in post-secondary vocational education is the instrumentation technician. This report is based on in-depth interviews with instrumentation supervisors in eight firms in Maine and the majority of this report is confined to a discussion of this one particular job.[1]

The Role and Impact of Maine's Paper Industry

Paper remains as the most significant industry and employer in the State of Maine and, as a consequence, its manpower needs should be of concern to the vocational educational community. There are 19 pulp and paper companies and 42 separate mills in Maine employing a total of 18,171 employees with the largest annual payroll of $198,000,000. The value of manufactured products in 1974 was $1,220,300,000. As an industry it probably has one of the most diversified labor forces in Maine. Investment in plant and equipment and new technology with the corresponding

[1]A copy of the interview guide is contained in Appendix A.

impact on manpower and educational needs, especially instrumentation, is the focus of this report. The annual average expenditure for modernization and equipment in Maine for the 10 year period 64-74 was $87,500,000. The expansion in plant and equipment for 1971-76 for projects, completed, will cost $549 million dollars. In 1976 pulp and paper companies will account for 88% of the total 296 million capital investment planned in the state for modernization and equipment. The trend for increased capital expansion in Maine, which is accompanied by technological change, parallels the national trend which had an annual average increase of 7% for the period 1960-72. The outlook statewide and nationally is for higher levels of capital spending.

One important impact of the capital investment and new technologies is on productivity. Output per man hour for all employees in pulp and paper (BLS data) increased at an average annual rate of 4.4 percent during 1960-73, well above the 3.4 percent growth rate for all manufacturing. This increased productivity was substantially above the average annual growth rate of 2.9 percent recorded by the paper industry in the 1950's. Productivity is expected to continue to rise at relatively high rates during the 70's, possibly by about 4% annually. Whether this rate can be achieved and sustained, however, will depend on several factors, availability of energy, pollution regulations which impact production methods and costs, and adequacy of raw materials. Continued introduction of new technology is likely to be one important source of reductions in unit labor requirements.

The significance of this analysis is that the pulp and paper industry is and will continue to be a major employer in Maine. What appears to be true is that pulp and paper in general, and more specifically the pulp and paper industry in the State, is witnessing large capital expansions with corresponding new technologies being introduced. Many feel the pulp and paper industry has been slow to introduce technoqical change. What is apparent is that if this were the case in the past, it is not true presently and all projections are that investments will continue.

Technological Change in the Pulp and Paper Industry[2]

Table 1 outlines the major technology changes in the pulp and paper industry. Because capital equipment is so costly, innovations usually involve modification and improvement to existing equipment and processes. Several plants in Maine are, however, introducing new paper machines which are most always accompanied by greater speed, increased fiber yield, and output per man hour.

Material handling systems in woodyards and woodrooms are being expanded. Modern conveyers have been introduced which do feature centralized control permitting wood and wood chips to move through processing with a minimum of handling operations. Substantial reductions in employment have taken place with a corresponding increase in output per worker. Paper companies in Maine have introduced both woodchipping facilities and mobile harvesters. New skill requirements have been introduced by these changes and, in at least one plant, courses in hydraulics and mechanics were developed by a vocational technical institute to upgrade the skills of skidder operators and maintenance men.

[2]A portion of this section is summarized from "Technological Change and Manpower Trends in Five Industries", U.S. Department of Labor, Bureau of Labor Statistics, 1975, Bulletin 1056. Other statements and findings are a result of plant interviews.

Table 1

Technology	Description	Diffusion
Mechanization of materials handling	Improved conveyor systems featuring centralized control are increasing productivity in wood handling and finishing and shipping departments. The storing and handling of chips instead of logs also have raised efficiency. Technology with the capability for "whole tree utilization" is expected to increase forest yields.	Mills increasingly will modernize materials handling functions.
Improved pulping technology	Innovations expected to improve yield and pulp quality include continuous digesters and more extensive use of computer control and instrumentation. Mechanical and semi-chemical pulping may increase in importance.	These innovations will continue to be introduced, particularly in larger mills.
Improved papermaking machines	Modifications of Fourdrinier and cylinder papermaking machines underway involve increase in machine speed and improved control. New technology in formation and drying also is improving performance and productivity. Twin-wire forming methods are being used more extensively.	These innovations are expected to continue.
Computer control and instrumentation	Electronic computers and advanced instruments increasingly are being introduced for control of pulp and papermaking equipment. Significant operating economies including gains in productivity and reduction in waste have been reported.	More widespread use of computer process control is expected. By 1973, more than 150 process computers were installed compared to 17 in 1965.
Pollution control technology	Technology to lessen air and water pollution is receiving increased emphasis and is being introduced more widely. The expense of pollution control equipment could contribute to the further closings of some small, marginally efficient mills.	Expenditures for pollution control equipment will increase significantly to meet new and more stringent anti-pollution regulations.

Innovations in pulping technology in the next 10 years are expected to improve both the yield and pulp quality and reduce pollution. Large capital investments in continuous digesters with computer controls will improve quality, reduce energy inputs, and provide for raw material savings. The Fourdrinier paper machine continues to be the basic technology in paper making. The "twin wire" machine, which moves the pulp in a vertical rather than horizontal plane, is in limited use in plants in Maine.

Computer control and instrumentation increasingly are being used for process control in pulp and paper mills. It is the pulp technology itself which has had a significant impact on instrumentation. Competition in the industry and the need for improved quality have, in effect, forced the industry to control their process much more closely. The Bureau of Labor Statistics reports that more than 150 process control computers were used in pulp and paper mills in 1973 compared to 17 in early 1965. Some sentiment exists among professionals in instrumentation that there is room in the paper industry for much more measurement and use of process control as both computer technology and instrumentation systems are further improved. The BLS reports that, at one plant, installation of a process control computer and new instrumentation on a paper-making machine reduced grade changeover time by 20 per cent, increased machine speed by 15 per cent, and improved machine efficiency by 2 per cent, for a net increase in production of 19 per cent. Advances in instrumentation have aided the use of computers. Some paper-making machines in Maine are computer controlled and use such advanced instrumentation as beta-ray sensors to measure paper weight, infra-red sensors to determine moisture content, optical sensors to indicate opacity, and electromagnetic sensors to measure thickness.

Employment trends

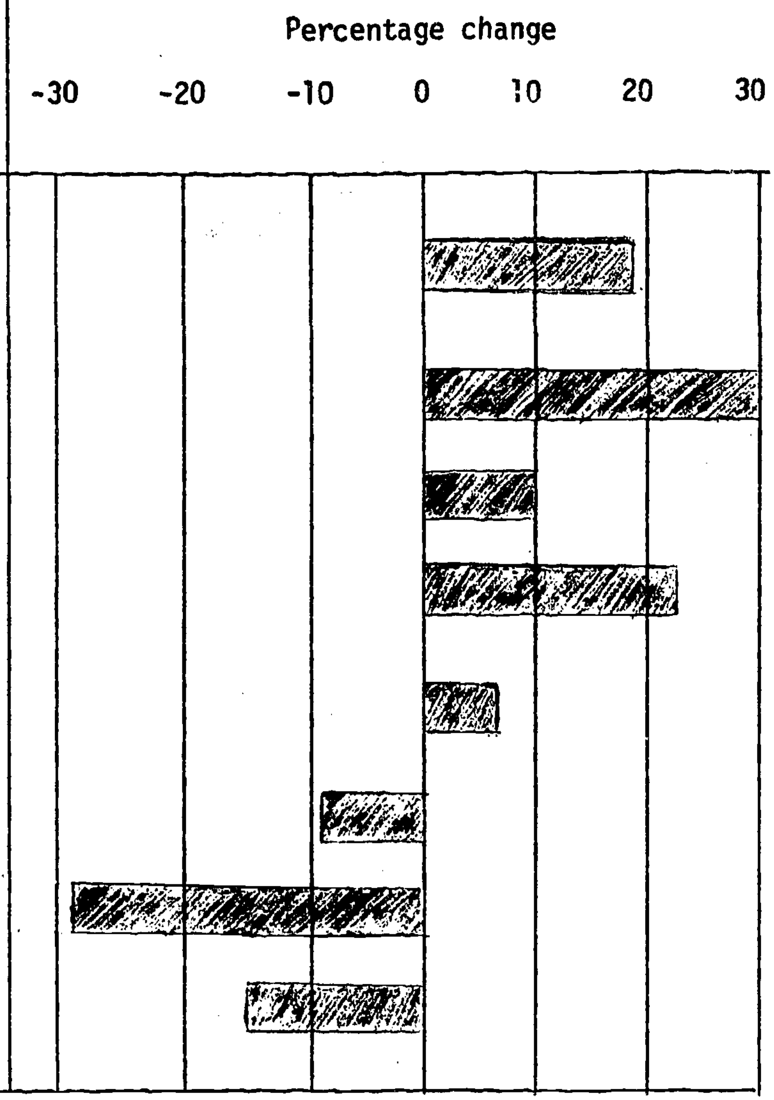
Census and Bureau of Labor Statistics data show that employment in pulp and paper has remained relatively stable over the last 13 years. BLS employment projections to 1985 anticipate an average annual growth rate of 0.4 per cent during 1973-85. Technological change will continue to alter the structure of jobs in pulp and paper mills. Table 2 describes the projected changes in employment in pulp, paper and board industry by occupational group. Job duties continue to change operative employee roles. Machine operators, for example, monitor more controls, are available in case of emergencies, and are increasingly required to oversee a greater work flow and relate one step to another.

Adjustments to these technological changes are handled either by specific training programs or are simply provided on the job. The BLS reports that in one mill which introduced process control, 16 employees, the computer manager and related staff received 2 to 6 weeks of formal classroom training. In addition, 84 workers, including instrument maintenance workers received from 6 hours to 2 weeks of on-the-job and classroom instruction on instrumentation. They suggest training of instrumentation repairers may be more intensive in the future since new instrumentation and control devices are more sophisticated and increasingly require a higher level of technical skill. The results section of this study report on the changes in instrumentation within 8 plants interviewed in Maine.

Table 2

Projected Change [illegible] t in the Pulp, Paper, and Boar[illegible]
Industr[illegible] cupa[illegible]ional Group, 1970 to 1980

Occupational group	Percent of industry employment in 1970
Professional and technical workers	8.5
Managers, officials, and proprietors	4.7
Clerical workers	11.3
Sales workers	1.5
Craft and kindred workers	19.8
Operatives	45.3
Service workers	2.8
Laborers	6.2



The Changing Role of the Instrument Technician

The technological changes described above (and the new environmental laws) are causing new jobs to be created and existing jobs to be changed. In most cases the changes result in less skills needed or if new skills are required they are ones that can best be handled by on the job training or experience. For example the operators running pollution control equipment can be easily trained by their immediate supervisor. Operators of the new paper machines have greater responsibility but the machines have taken over much of the measurement and adjustment that was formerly done by operators on older equipment. Someone has to maintain this equipment and toubleshoot problems. This role has often fallen on the instrument technician. In some plants the role is filled by several trades including electricians and pipe fitters but in most of the plants visited there is a separate trade called instrumentation or instrument technician. To do an adequate job requires a knowledge of electronics, electricity, pneumatics, physics, some chemistry, and, of course, the process itself.

The field of instrumentation is changing. This change is occurring through the introduction of modern equipment which includes more automation, more closed looped systems, requiring the need for a greater use of instruments. Competition in the paper industry requires closer tolerances and higher quality. Both the job duties and the skill requirements within instrumentation have increased.

The first instruments used in pulp and paper were primarily pneumatic which required some basic plumbing and pipe fitting skills. Signals measuring changes in pressure or temperature, for example, were carried by tubes to the necessary gauges. More recently, electronic measures have been introduced which require an understanding of electronics. As more and more measurements are being taken, more and more of the process is being monitored. In the industry these processes are described as "loops" and it is not uncommon in a plant producing 600-800 tons of paper per day to have as many as 5,000 loops which are monitored in one way or another. [illegible] the process of paper making measured but so are such functions [illegible]ution control and power generation. Traditionally pulp and paper companies perform a wide range of operations, perhaps more than many communities in Maine. Thus, the changes in the process itself, allied activities, the introduction of electronic measuring devices, and the closing of more loops in pulp and paper has placed new demands upon the field of instrumentation.

One of the significant changes reported by the instrumentation supervisors was the increased need for a better understanding of the processes involved. The instrumentation role was defined much more broadly than merely the maintenance of equipment. Supervisors felt members of their group were "trouble shooters" called in to correct a malfunction in the process first diagnosed by an improper recording. As a result, they became very familiar with the processes in a pulp and paper plant. Consequently, the instrumentation department and job is viewed as a high status one, often sought by those with seniority who may or may not have the necessary qualifications.

One result is quite clear, the skill requirements for instrumentation technitions have increased considerably within the last 5-10 years. Job duties have become more complex. Both of these changes have implications for the necessary education and training in the field of instrumentation.

In the first instance, for example, more specific training knowledge is required in the area of electronics. In the second, a greater understanding of process and systems control is placed upon the instrumentation department. There would seem to be a role for VTI's to play in the educational process; there is general agreement that an instrumentation worker is a faster worker and a better troubleshooter if he understands the basic ther[illegible] niques that he is working with. That is, the worker should know and be able to apply the principles of physics, chemistry, electronics, and perhaps mathematics. These are all subjects that can be most efficiently taught in a school setting such as at VTI.

Current Methods of Skill Development

A need for training does definitely exist. At the present time this need is being met in several ways by the plants visited and include:

1. training conducted in-house by plant staff, most often the instrumentation supervisor
2. correspondence courses
3. evening courses taught by vocational and adult education personnel
4. short courses, 1-2 weeks, taught by equipment manufacturers
5. Professional Society which develops curriculum material
6. on the job training
7. Vocational Technical Institutes

In Plant Training Programs

In only a few plants does the instrumentation supervisor conduct formal courses. Most of his teaching and training, if done, is on the job. No observations were made of any actual training sessions by supervisors but this approach introduces both some advantages and disadvantages. Certainly training done by the supervisor is direct and job related. There is no substitute for relating the learning experience with the work itself. Transfer of learning is immediate. On the other hand, the instrumentation supervisor as a teacher-trainer poses some difficulties. First, it is assumed that all supervisors are effective teachers. This assumption, of course, may not be correct. Secondly, a learner finds it difficult to admit to his teacher-trainer and supervisor that he does not understand. So, despite some advantages which might arise by handling instrumentation instruction internally, it is offset by some faults. Interviews with the supervisors revealed that job demands required much of their time and they had little opportunity to present training programs. In most plants, the supervisor works the day shift and this deals with problems that may be passed on to him from the evening. In one instance the supervisor "made himself available" to work with employees who received released time during work hours to complete correspondence courses. In the plants interviewed the supervisors were not a significant factor in formal course offerings.

Correspondence Courses

Correspondence courses were used by nearly all the companies in conjunction with their apprenticeship program. They are well structured and have been adapted to meet many of the needs of company training programs and include such offerings as Physics, Basic Instrumentation, Electronics, and Electricity. The procedure differs. Some companies allow plant time in which to work on lessons, in other situations the employee is required to complete assignments on his own time. Despite the structure of these correspondence programs some obvious problems arise: they are not directed to immediate plant circumstances, there is a lack of student-teacher interaction, and the courses can not keep pace with current technological changes. The correspondence courses do, however, serve a useful function for teaching basic concepts not subject to frequent change.

Evening Courses

In the past and at present, several plants utilized the services of either adult education instructors within the community or vocational education personnel. In one instance electronics was being taught to a group within instrumentation at the plant site. In another case, basic courses were being taught through local vocational education offerings. The use of continuing education was not used extensively although members of the instrumentation groups within the plants were described as "motivated and willing", for the most part, to take advantage of available educational opportunities. Some attempts in the past were made by several companies to develop joint course offerings between a number of plants and vocational technical institutes but apparently these efforts did not materialize. The complexities of new innovations point toward the need for refresher courses and the introduction of both basic and specialized courses to personnel in the instrumentation field. It did not appear that the existing expertise provided by various educational institutions was being utilized in either in-plant training programs or apprenticeship programs operated by joint union-management committees.

Equipment Manufacturers

Equipment manufactureres are an excellent source for specific training in instrumentation. A wide range of course offerings are provided which are principally related to the specific equipment produced by the manufactu . Both the laboratory courses taught by the manufacturers and the material available through them provide a good base for courses in instrumentation. Discussions with representatives from Foxboro equipment company revealed that each class comprises a wide range of backgrounds and that it is not unusual to have both Ph.D.'s and students with less than a high school educational level in a single class. The courses offered by the equipment manufacturers play a very relevant role in the training of instrumentation. They are well organized, compact, directly related to specific instruments and their use, and the companies have available the most modern equipment. There does exist an element of "salesmanship" in this educational process but it was felt by the one manufacturer interviewed attempts to sell their specific equipment were not a very significant element and the salesmanship was only implicit, not explicit, in the presentations.

Professional Societies

The Instrument Society of America is the professional organization representing the field of instrumentation. They have available detailed instructional material including lecture notes, slides, illustrations and other training aids. A suggested two year post-high school curriculum entitled "Instrumentation Technology" was developed jointly in 1964 by the ISA and the U.S. Office of Education. It is currently under revision. The professional society ISA is one important link which provides the field with the most recent developments in instrumentation. The society has, as one of its objectives, education and training and provides up to date instructional aids. The ISA, in addition to the equipment manufacturers, is a very important and critical element in developing both the present and future training curricula in instrumentation. Although the ISA is represented by areas other than pulp and paper, specific publications do exist in this field and there is a specific division designated Pulp and Paper Industry.

On the Job Training

On the job training probably is the most frequently used technique for the training of instrumentation. It is coupled with a joint union-management apprenticeship program which requires approximately 8,000 hours of work and takes about four years to complete. Appendix C is an example of one part of an apprenticeship program. Formal instruction quite frequently consists of correspondence courses which allow the apprentices to proceed at their own rate. Plant personnel may conduct some of the formal course offerings in conjunction with the apprenticeship program. On the job training has the one decided advantage of providing information on the wide range of processes involved in pulp and paper. OJT is a critical element in the training of an instrumentation person.

Vocational Technical Institutes

Central Maine Vocational Technical Institute is the only post-secondary institution in Maine that has a separate curriculum designed to provide students with skills in process control or instrument technician. The program began in 1967 and initially had a sizeable number of students enrolled. The program is now dormant; the last full time student in the program was in 1972. Although a coop program is also listed in the catalog it has never been implemented. It is difficult to pinpoint exactly why the program was not more successful since the field is growing and there is a constant need for Class A journeymen. The program did have difficulty attracting students because instrumentation is a little known trade of which few persons were aware. Graduates also had difficulty getting jobs, at least immediately, although most of them were eventually placed in jobs closely related to their education and training. It is reported the course was also difficult to teach because most students were not able to relate their classroom work to the real world because they had no experience with the problems that the courses were designed to help them solve.

In interviews with industry personnel the program in instrumentation was, for the most part, viewed positively. One firm was very critical of the outdated equipment that students had had to work with.

Summary of t[illegible] [illegible]ograms

The data collected support the premise that a need exists for the training of people in the instrumentation field as evidenced by the many and diverse ways in which this need is being met. The number of people employed within the field of instrumentation has doubled over the past 10 years and there is speculation that increased investment in equipment and mechanization will require an expansion at the same rate in the next 10 years. The technology in instrumentation is changing and the need to meet this change is reflected in the different types of training programs and aids developed. The real question is whether the present system of training is the most effective one. What appears to be lacking is a high degree of formal interaction between student and instructor. There is a heavy reliance on correspondence courses and, of course, on-the-job training. Current instrumentation employees do need refresher courses and in a few instances up-grading is taking place.

Career Opportunities in Instrumentation

The opportunities for jobs in instrumentation are increasing and are tied directly to capital investments. Generally, plant expansions mean more automated equipment and, in turn, an increased need for instruments. One instrumentation supervisor interviewed was anticipating an increase in his group from 15 to 27 within the next year.

Entry into the instrumentation group is not direct. In all plants interviewed, positions in instrumentation were filled through the normal job bidding process. Apprenticeship programs are the customary route which require approximately three to four years to complete. Selection of apprentices is done via a union management committee. Seniority, not education or training, is the primary basis for selection. Some firms administer tests but they are not used in the selection process. In one plant, the company did introduce examinations for selecting apprentices, however they were used only once because union demands required they be discontinued.

In some instances credit has been given for vocational education training which reduced training hours but in no instances have vocational educational graduates become instrumentation journeymen upon initial selection. One very common career ladder is for workers to enter the labor pool and then bid for a job within instrumentation. This process could take from 1-7 years before an eligible applicant would actually begin an approved apprenticeship program. An average of 3-4 years is more typical. A VTI graduate in an appropriate field might have an advantage in competing for an instrumentation apprenticeship opening. In some plants successful completion of a two year VTI program in an appropriate subject would substantially reduce the number of years in apprenticeship.

Some union contracts do allow firms to hire Class A journeymen on the open market if internal qualified applicants are not available. Other collective agreements are more restrictive and require exclusive selection from within the work force.

One additional factor is important when considering a career in instrumentation. Unlike electricians, plumbers, and auto mechanics, it is not very feasible for instrumentation graduates to operate a private practice. Although cities and towns and other types of processers use instruments there is not sufficient demand to support an individual repair service. Thus, instrumentation opportunities in Maine are restricted primarily to the pulp and paper industry. Other options exist in such areas as food, chemical, and petroleum but these are not available in Maine.

Necessary Training and Background for Instrumentation

The interviews pursued the question of what is a desireable background and training for a good instrumentation person. Respondents were not specific and tended to identify good work habits such as the desire to work, motivation, good problem solving skills, an understanding of the pulp and paper process, analytical mind, good communicative skills, and naturally curious as much as specific skills or educational backgrounds.

Certainly very basic to the field of instrumentation is a good understanding of the principals of Physics. The measurements in pulp and paper deal with variations in temperature, pressure, density, flow, viscosity, and speed. The introduction of electronic equipment now requires a competent instrumentation worker to understand and interpret schematics and the principles of electronics. Some basic mechanical skills are important. One supervisor, in defining what he looks for in the background of applicants replied, "if he (the applicant) says he is interested in electronics, television repair, and etc., he'll make a good instrumentation worker." No attempts have been made to relate specific skill training with success on the job although personnel managers would like to evaluate this area in attempting to validate testing and selection techniques.

One common profile of a successful instrumentation technician was former military personnel who had worked in some capacity in electronics. In at least one case, these qualifications permitted a journeyman classification and thus omitted placement as an apprentice.

In summary, the basic skill requirements of an instrumentation technician have not been clearly defined by most respondents interviewed. Principles of physics and electronics are important but so too are the more intangible elements defined as being methodical, inquisitive, and having problem solving skills. One of the reasons for this lack of clear definition in basic requirements is that employees are not hired directly into instrumentation (other than a journeyman in some companies), thus firms have limited control over the selection of personnel other than that where it can be exercised via the joint union-management apprenticeship committees. It would be interesting and worthwhile to develop improved selection procedures. Supervisors quite readily identify the "best instrumentation personnel" and thus there does exist an excellent base on which to develop improved selection techniques. To date, none exist. This condition is a problem to be discussed by union and management.

Summary and Conclusion of Results

1. There is a growing trend nationally and in the state for the need for more instrumentation technitions. This demand is directly related to capital expenditures for new paper machines which nearly always include new technologies. All evidence suggests that higher levels of expenditures will be made than at present with the corresponding impact on the use of instruments.

2. A real need was demonstrated for training and skill development in instrumentation. At present this development takes place in the form of correspondence courses, in plant training, programs by equipment manufacturers, and information supplied by equipment manufacturers. There is very little input by vocational education institutions although a program did exist.

3. Career opportunities are excellent in the field of instrumentation. It is viewed as a high status, high skilled job within plants and has a good wage structure. Past experience indicates that there are not many upward ladders in instrumentation and in fact it represents the end of a specific career ladder. It is uncommon for instrumentation technitions to be promoted to a supervisory position outside of their department despite the general knowledge they gain in the process of papermaking. In the firms interviewed it was rare for instrumentation technitions to seek a transfer from this section. Entry into instrumentation is not easy. Unless hired as journeymen, all positions are filled internally which means that a job bidding occurs.

Consequently, it may take as long as 3-4 years before a person could bid and be selected for a technition's job. Thus, vocational technical graduates might spend up to eight years, or as little as three, before they become instrumentation journeymen.

4. Few career opportunities in instrumentation exist in Maine outside the pulp and paper industry. Opportunities do exist outside the state in any number of industries, aerospace, biomedical sciences, metals industry, power industry, and transportation. There is a small demand in Maine for instrumentation technitions in power, textiles, food, and pollution control. It is probably not feasible to establish a "fee for service business" on a full time basis.

5. Very little input by formal educational institutions currently exists. Some courses are taught both in plant and at technical schools which are indirectly related to instrumentation but no specific courses in instrumentation are now offered.

6. In the plants studied, no detailed specific job descriptions existed describing the job specification for instrumentation technitions. Selection for entry level jobs via the apprenticeship program is accomplished by union-management committees which use seniority as the primary factor.

7. There are few, if any, formalized techniques such as test which are used in the selection process. Thus, very little evaluation of specific skills takes place. Previous formal training is an advantage

in the job bidding process but is not an absolute guarantee for placement within instrumentation.

8. An understanding of process control systems is critical as a foundation for instrumentation. The best instrumentation technitions have the capacity for problem solving which has underlying it a sound knowledge of the process.

9. Current collective agreements place severe restrictions on expanding formal instrumentation courses by vocational technical institutes with the expectation that direct placement of students will occur. This situation does not seem much different, however, than from other skill trades which require apprenticeship training.

A Conceptual Framework

This study has explored the implications of the changes occurring in the paper and pulp industry for vocational education in Maine. This section explores in a more general way, using the pulp and paper industry as an example, some of the problems involved in maintaining a vocational education program up to date with the needs of a State's major industry.

There are likely to be many new jobs or changes in existing jobs occurring at any one particular time. These changes can come from several sources including legislation, technology, and growth. It is important both for students and employers, that vocational education be current and match the changing needs of employers. This is a tall order. There are at least three major problems involved. First it is difficult to identify those job changes that are taking place; there appears to be no systematic method to do so. A second problem is separating out those job changes that are important for vocational education and curricula development.

It is unlikely that more than a small minority of job changes will have any direct implication for occupational education. Most change is designed to be labor saving, either in reducing the numbers needed to perform some function or in reducing skill requirements. The change introduced in the woodroom in pulp mills is a good example where the numbers of employees have been reduced and productivity has gone up. A great many changes are occurring in Maine's pulp and paper industry, including very significant technological changes. The changes are altering the nature of existing jobs, but insofar as implications for vocational education are concerned, much of the change seems to be centered around one particular occupation--instrumentation. Change in job requirements for many operator roles is being handled by on the job training programs. Employers seemed to see little need for further formal education in many mechanized jobs.

A third problem in ascertaining implications for vocational education is the uncertainties caused by the realities of the labor market. Although particular skills may be most efficiently obtained through formal education, custom or labor contracts may dictate otherwise. Unless changes are made in the structure of the labor market which allow firms alternative methods of hiring workers who appear to be the most trained, they may be unwilling or unable to use the most efficient forms of skill development.

The following diagrams describe the conditions outlined above. The working hypothesis is that the successful performance of most jobs requires both education and training and there is considerable scope for substitution between these two forms of skill development. In Diagram 1 the isoquant aa' shows the various combinations of education and training needed for successful performance of a particular job, say a first class machinist, in a particular firm. Training, measured on the verticle axis, is a broad term and can range from learning or skills acquired in formal training programs, abilities obtained from on the job training, or from experience in a specific or related job. On the horizontal axis Education is the formal preparation normally obtained in schools. As the isoquant aa' is drawn, minimum levels of education and training are required. The minimum level of education would be measured on the horizontal axis by OE. The minimum level of training is measured by OT. For example, even an individual with a Ph.D. in engineering would need

Hypothetical Education and Training requirements

a' For a First Class Machinist

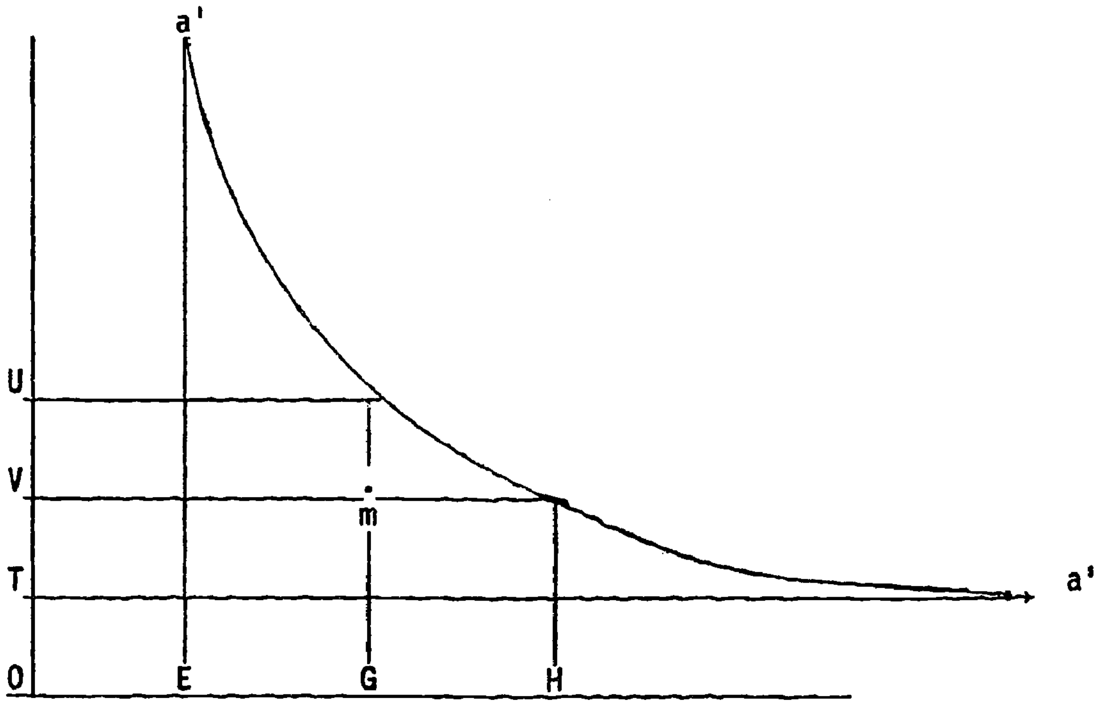


Diagram 1

at least OT amount of training before he could adequately perform the job of first class machinist; on the other hand, a person with less than OE education could not possibly qualify for the job even with an infinite amount of training. Between these extremes there is considerable scope for tradeoffs: a person with more education will need less training; an individual with less of an educational background will need more training. Given a minimum level of education there are many different combinations of education and training whereby an individual can acquire the skills needed to adequately perform any particular job.[1]

The diagram assumes a complete substitutability between education and training but does not assume any equality in cost between this substitutability. As the minimums are approached, the substitution between training and education becomes less and less favorable in terms of cost. For example, as the minimum level of education is approached, it takes more and more training to offset the same amount of education. Likewise, as the minimum level of training is approached, it takes more education to substitute for the lack of training. Under normal conditions the most desireable condition to be in would be one in the center section of the isoquant.

Given the conditions shown in Diagram 1, an employer needing a Class A machinist and having complete discretion over hiring requirements would have a number of options open to him. If he were hiring someone right out of school he could hire an individual with OG education and provide him with OU training or, alternatively, hire an individual with

[1]For some alternative combined methods of how first class machinists in Maine actually have learned their skills, see James A. Wilson and David F. Wihry, "Investment Planning in Vocational-Technical Education", Manpower Research, Project, Orono, 1971.

OH education and provide him with only OV training. There is, of course, another alternative open to the firm, namely to hire someone as represented by point m, an individual with more than the minimum amount of education and already with substantial amounts of training and experience but insufficient to adequately perform the job (a machinist's helper, for example). In this instance only additional training as measured by UV would be necessary to move the person to the minimum level of training and education. Without any restrictions the firm would presumably make the most profitable (least costly) choice from among the alternatives open to them. The costs would depend upon the wage rates and the cost of training. However, as discussed more fully below the firm may not have much discretion because hiring procedures for particular jobs may be controlled by custom or labor contracts.

Relationships such as these can be estimated for every job in a firm but with considerable variation. Not every job requires occupationally oriented education and thus is interesting for vocational education planners. Some of the possibilities are shown in Diagram 2. Such jobs as marketing or engineering require more education or a different kind that is normally provided in post-secondary vocational education institutions. This situation is illustrated with isoquant ee'. Many industrial jobs would have a very flat isoquant such as that depicted by ff', representing types of workers which would require a certain amount of training, but little else, at least in the educational range normally reached by most workers. Such flat isoquants describe most semi-skilled jobs. The general problem for vocational education planners is to identify those occupations that have a high need for vocational education, Training and Education Required to Adequately

Perform 2 Specific Jobs

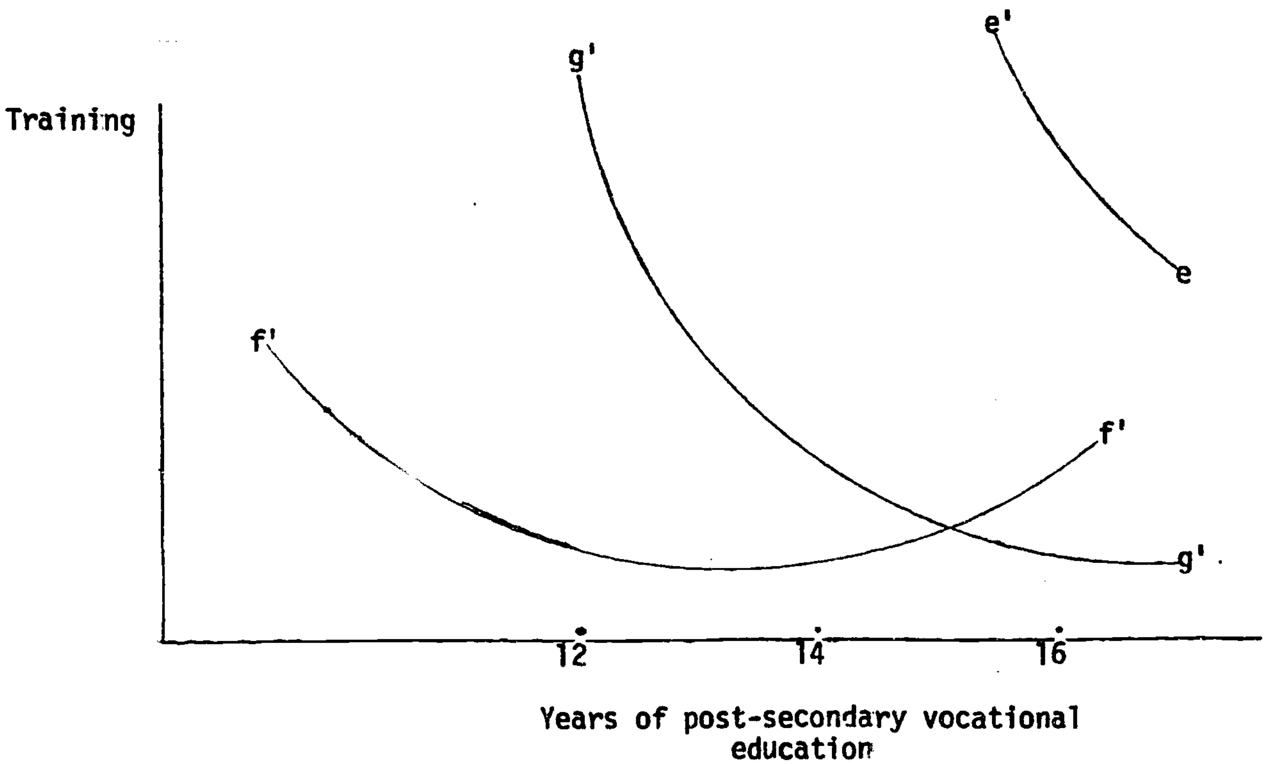


Diagram 2

that is, whose isoquants would be similar to gg' where the education that is needed would be best served by occupational oriented education.

The effects of change in a job's characteristics are illustrated in Diagram 3. The requirements for the old job are shown as isoquant aa'; bb' and cc' represent the effects which might arise out of technological change. In most cases the effect of technological change will be to shift the isoquant downward and become more flat, such as the change from aa' to bb'; in other words, less education and less training would be required for satisfactory performance of this particular job and the substitution possibilities of training for education would become more favorable for training.

In a few cases there would be a significant shift upwards in the isoquant, such as from aa' to cc'; indeed for instrumentation it would appear that the isoquant shifted upward and became more steep. It is shifts such as the one to cc' that vocational education planners must be the most aware of since it may be definitely more efficient for the firm to increase its educational requirements for the job in question.

However, it may not be very feasible for an employer to make such an increase in educational requirements, even though it may be a more efficient solution. One of the most difficult problems faced by vocational education planners is that most jobs in a firm are not at the entry level. The firm usually does have discretion over hiring requirements for entry level jobs and usually can be counted on to make the most efficient choice. However, in a highly structured internal labor market which characterizes most industrial firms, custom or labor contracts will dictate that most jobs are filled from within by predetermined methods. Some of the necessary experience and training will

Effects on Educational and Training

Needs of Change in Skill Requirements

For One Particular Job

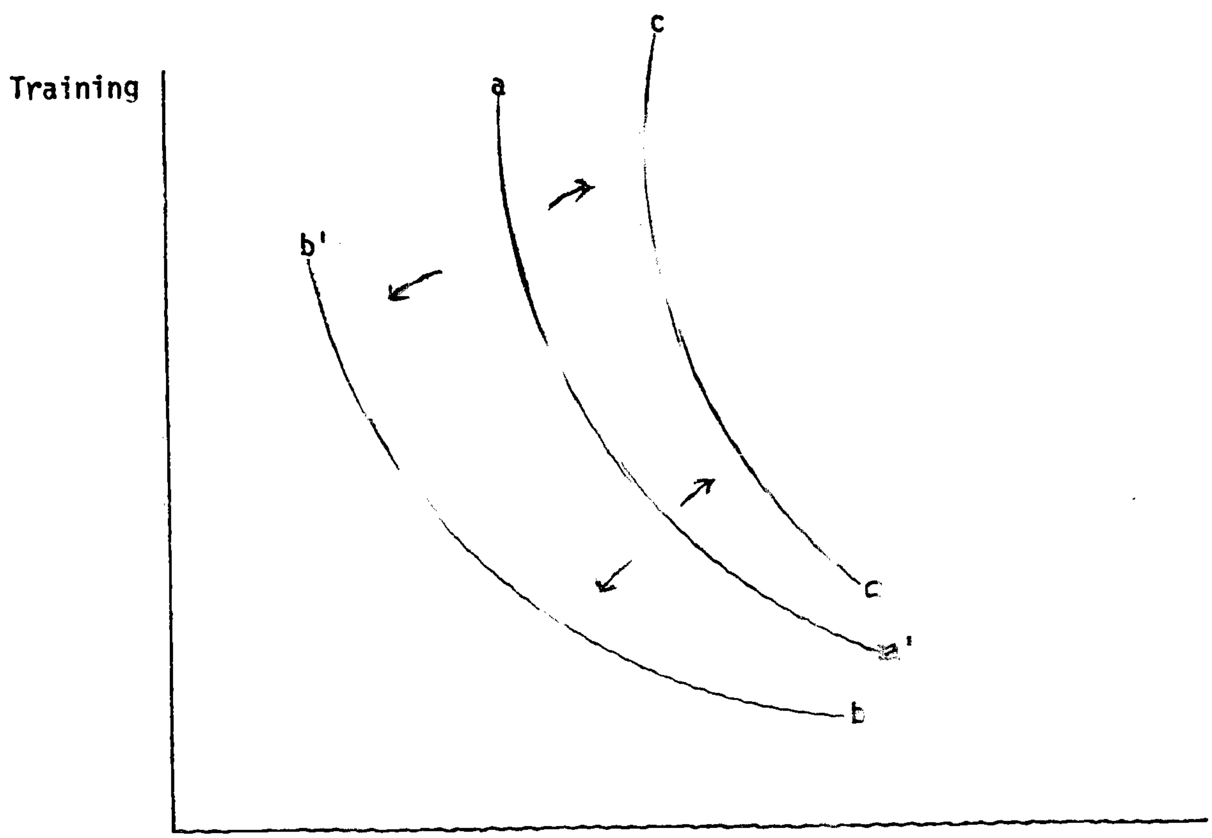


Diagram 3

have already been obtained on the job. The skills lacking are made up by additional training, either on the job training or through some more formally structured process. The employer has little discretion over hiring requirements for jobs that are normally filled from within the firm. If the job in question is one of many jobs that are filled by rules governed by custom or a collective bargaining agreement (for example where jobs are filled by choosing apprentices out of a general labor pool) it may not be efficient for the firm to change hiring requirements for all jobs just to satisfy the changing requirements of one particular occupation In addition, it may be very difficult to change hiring requirements for one particular job. The latter can be done. Custom can be violated; labor contract terms can be changed, but such changes would likely entail political as well as economic costs and it is only problematic whether any one particular employer wants to or is willing to try to make the necessary changes.

The implications of the analysis above are as follows. Change is taking place in most industry today, causing significant modifications in job requirements and in turn causing significant changes in educational and training needs to satisfactorily perform those jobs. It is very difficult, however, to identify those changes that have implications for vocational education programs. First of all, it is difficult to identify new jobs and/or changes in existing jobs. Secondly, many job changes have little implication for vocational education since skill requirements are lessened. Third, even in those cases where there is substantial raise in skill requirements, it is problematic whether these changes will be reflected in higher educational requirements imposed by the firm or indeed any premium paid to higher education since, in most cases, skill development can be handled by changes in training programs within the firm. In a unionized situation, firms have to undertake bargaining changes describing the manner in which particular jobs are to be filled. Such an approach is likely to introduce political as well as economic problems whose outcome is difficult to predict.

Recommendations for Vocational Education

1. Although the need for instrumentation technicians is increasing, this report can not, at this point, recommend the institution of a two-year curriculum. It is recommended that a more detailed study be made of the anticipated demand for instrumentation technicians in the next five years. A labor market survey of both the paper industry and others who utilize these particular skills should be made before the finalization of any curriculum.

2. In conjunction with one above, it is recommended that a specific craft committee for instrumentation and process control be formed to investigate the needs of industry and the ways in which these needs may be met by vocational education. The ISA (Instrument Society of America) does have a state chapter which would be an excellent place to begin.

3. A cooperative education program between the paper industry and the vocational educational institutions should be explored. The diversity of skill requirements in pulp and paper would provide a wide range of educational experiences for students and extend beyond work in instrumentation.

4. The data suggest that Vocational Education Institutions can play a more direct role in providing courses which would upgrade present employees and provide training for new apprentices. Specific ways should be explored to see how such a program

might be accomplished. The heavy reliance on correspondence courses, although serving a function, may not provide the most desirable learning situation.

5. Model curricula exist including visual aids and teaching materials. If progress is made toward the development of a specific curriculum, the specific resources available through equipment manufacturers and the ISA should be explored. Equipment manufacturers do contribute equipment for laboratory use.

6. The issue of specific versus general training still exists. Instrumentation is becoming more technical and general skills remain critical. Problem solving, diagnosis, as well as an understanding of basic principles are an important aspect of an instrumentation worker. These are not easy skills to develop however they suggest a need for a broad, not narrow, background.

7. Instrumentation technician is a growing field and the work is interesting and useful. Vocational technical students should be made more aware of career opportunities in this field.

Appendix A

Methodology

Methodology

A structured interview guide was used in the study. It was determined the interview process would allow a greater degree of flexibility in pursuing questions concerning technological change and its impact on vocational education. In the initial stage contact was made with several personnel directors in pulp and paper firms in addition to others closely allied with the industry. Discussions centered around the technological changes that have taken place within the last five to 10 years and anticipated changes the next ten years. Several areas were identified; the process itself where paper machine operators now operate large, complex, and relatively automated machines and the environmental control area where recent legislation has imposed standards for controlling waste products. Further exploration seemed to reveal that basic to these jobs whose duties have been either changed in the case of machine operators or newly created in the case of pollution control, is the introduction of instruments to monitor and control processes. Thus, the study's objectives were more narrowly defined and focused upon the one area of instrumentation. The increased need to measure such factors as pressure, temperature, velocity, density, and flow has placed new demands upon the paper industry.

Instrumentation supervisors in eight paper companies were interviewed. Normally the interviews lasted between 1 1/2 and two hours. Questions in relation to the change itself, entry level positions, career opportunities, labor markets, current methods of training, apprenticeship programs, and future needs were explored. Not only were answers to the questions in the interview guide sought, but in the interview attempts were made to explore areas that may have been overlooked in developing the general thesis of the study. In addition to the instrumentation supervisor, interviews were conducted with personnel directors and in some firms members within the instrumentation group. One day was spent with the training director of Foxboro Instrument Company, one of the major suppliers of instruments for the pulp and paper industry. The responses to the questions are analyzed in the report.

Appendix B

<u>Interview Guide</u>

Hello, I'm ________________ of UMO. We are investigating the effects of changing technology on the jobs in paper industry and the implications for vocational education in the State, both in secondary schools and in the VTI's. There are three particular areas that we see as having shown the great change: in the maintenance area jobs in instrumentation; in process the jobs in papermaking, and finally those new jobs that have arisen because of environmental laws and requirements.

First I would like to ask you about the jobs in instrumentation.

INSTRUMENTATION:

1. Do you have a separate (department) (group) in instrumentation?
2. How many persons are in this group (department)?____________
3. Do you have particular job descriptions for these jobs? If written could we have a copy? (We want to make sure that we have a common group of jobs in each plant where we interview.)
4. How have these jobs changed over the past five years?_________

   ____
5. What kind of changes do you anticipate over the next five years?

   ____

   How many people do you think will be hired in this group over the next five years?______________(taken into account retirements, turnovers, promotions etc.)
6. How are these jobs usually filled? (That is are jobs normally filled from within the plant or from without) If from within the plant, is an apprenticeship program necessary. (If no apprenticeship program skip to section #7). If yes, continue below:

a1. How many years is the apprenticeship?_______ Does it vary?___

a2. Where does he get the training?____________Is any of it done outside the company, by whom?

b. On the average how long is a person with the company before he can enter the (pollution control), (papermaking) apprenticeship program?________________

c. What is the entry level job?______________Are there any exceptions? ______________

d. If a person would enter at that entry level job, about how long would it be before he became a (papermaker), (journeyman), (pollution control tecnician)? $_________, at the entry level ___________.

e. What would he be earning as a (journeyman), (pollution control technician)? $_________, at the entry level__________.

f. What are the career opportunities for a person after he gets to be a (papermaker), (journeyman), (pollution control technician)? Do persons leave the section? Yes____No____Where do they go?_____ _______________Is that a promotion? Yes____No____Would they use the same skills_____________? Are they supervisory opportunities? Yes____No____ About how long does it take to move to a supervisory position?__________________________

g. Are there specific educational requirements to get into the (papermaker), (pollution control) apprenticeship program?_______ What are they?____________________

____

h. Do you have any educational preferences? Does the firm prefer a particular educational background for (papermakers), (instrumental), (pollution control)? What is it?________

____

i. Does a person with a vocational school background (secondary school) have any particular advantage (e.g. have a better chance to get picked; finish apprenticeship more quickly; or less chance of failure?)____________Why?________

____

j. Does a person with VTI degree have any particular advantage? How many people have had a vocational education background?_____ If so does that hold true for any VTI program? Or some particular VTI program?__________Can you explain________

____

k. About how many apprenticeships to you initiate each year?

Papermaker________________

Pollution control___________

Instrumentation_____________

7. Do you ever hire anyone from outside the company directly into:

instrumentation____________

pollution_________________

papermaking_______________

If no skip to question 8. If yes, continue.

a. How many have you hired in the last five years?__________

b. What was the entry level job?____________

c. What are the career opportunities for a person after he gets to be a (papermaker), (journeyman), (pollution control technician)? Do persons leave the section? Yes____No____Where do they go? ____________________Is that a promotion? Yes____No____ Would they use the same skills?____________Are they supervisory opportunities? Yes____No____About how long does it take to move to a supervisory position?__________________

d. What is the educational background of those hired?____________ Is there any common core?_______________

e. Where did they get their previous training?__________________

f. Do you have any educational preferences? Does the firm prefer a particular educational background for (papermakers), (instrumental), (pollution control)? What is it?_____________

____

g. Does a VTI graduate have any preferences?__________________ Do you look for any particular VTI program? Yes____No_________ If yes, which one____

8. Have there been failures; that is people who just couldn't do the work: apprenticeship________ newly hired journeymen___________ present workers__________? If so were the problems associated with educational background of the individuals?

9. How are current workers kept up to date? Do they go to school? What schools?

10. Do you think that these hiring practices/educational requirements/ preferences will change in the near future, say the next five

years (we hear a lot about how everything is becoming more and more sophisticated; will these jobs need a better or different educational background than present workers have?

11. If a VTI graduate in a program that is particularly appropriate for your paper company (pollution), (instrumentation), (paper-maker) were to take a job with your company:

a. Where would he start?______________________________

b. About how long would he be there?_________________

c. What are his chances of getting into an instrumentation job? (or inst. app. program)?

d. How long total time would it take him before he enters the 1st level in (instrumentation), (pollution), (papermaking).

e. Would he get any credit, or have an advantage from his VTI education? Yes____ No____

f. What sort of further career or ladders on opportunities are there for promotion.

g. Specifically are there opportunities for supervisory positions: Does his educational background give him any advantages?_____In what way?

Appendix C

Sample Course - First Two Years of a Four Year Apprenticeship Program

INSTRUMENT APPRENTICE CLASSROOM TRAINING

First 1000 Hours - Classroom

1 - Plant Safety - 10 Lessons, TPC	20 Hrs.
2 - Introduction to Electricity & Electronics- 10 Lessons, TPC	20 "
3 - Basic Shop Math - 9 Lessons, TPC	18 "
4 - Basic Pneumatics - 7 Lessons, TPC	14 "
Total	72 Hrs.

Second 1000 Hours - Classroom

1 - Basic Pneumatics - 3 Lessons, TPC	6 Hrs.
2 - Basic Blueprint Reading - 10 Lessons, TPC	20 "
3 - Pneumatic Trouble Shooting - 10 Lessons, TPC	20 "
4 - Reading Schematics & Symbols - 7 Lessons, TPC	14 "
5 - Basic Hydraulics - 6 Lessons, TPC	12 "
Total	72 Hrs.

Third 1000 Hours - Classroom

1 - Basic Hydraulics - 4 Lessons, TPC	8 Hrs.
2 - Hydraulic Trouble Shooting - 10 Lessons, TPC	20 "
3 - Principles of Automatic Process Control Instruments-ICS 6305 A & B	20 "
4 - Automatic Process Control Valves - ICS 6307-1	10 "
5 - Fluid Flow Measuring & Control Instruments ICS 6308 A & B	14 "
Total	72 Hrs.

Instrument Apprentice Classroom Training (Cont.)

Fourth 1000 Hours - Classroom

1 - Fluid Flow Measuring & Control Instruments - ICS 6308 B	6 Hrs.
2 - Process-Pressure Measuring & Control Instruments - ICS 6309 A & B	20 "
3 - Temperature Measuring & Control Instruments - ICS 6306 A & B	20 "
4 - Understanding & Using Electronic Diagrams - ICS 2021-1	12 "
5 - Fundamentals of Electronic Instrumentation & Control - ICS 6525	14 "
Total	72 Hrs.